BLOWER OPERATED AIRKNIFE WITH AIR AUGMENTING SHROUD

RELATED APPLICATION

[0001] This present application is a continuation in part of Application Serial No. 10/037,142 filed December 21, 2001.

FIELD OF THE INVENTION

[0002] The present invention relates generally to blowers, and more particularly to a blower-operated airknife for directing an elongated narrow width curtain of air.

BACKGROUND OF THE INVENTION

[0003] Blower operated airknives are known for directing elongated air curtains for various purposes such as, for example, drying, cooling, or cleaning items conveyed transversely through the air curtain. Such airknives typically have a narrow elongated slit-like discharge orifice and are supplied with a low-pressure air that is channeled through the discharge orifice in a downwardly or outwardly directed curtain of air. From an economical standpoint, it is desirable to use relatively low-pressure blowers with such air knives, such as blowers that operate at pressures on the order of 5 psi.

[0004] A problem with such low air pressure operated airknives is that the volume and velocity of the discharging air can be limited, which in turn can limit the effectiveness of the air curtain, including its effective transverse width, i.e. the width of the curtain in the direction of travel of items conveyed through the air curtain. Since such blower-operated air knives typically direct an elongated narrow width air curtain in a straight downward direction, it also sometimes can be difficult to apply the pressurized air stream against front and rear sides of a moving object. It also usually is not possible to limit the air flow to specific separated surfaces of passing objects.

OBJECTS AND SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to provide a blower-operated airknife that is adapted for more efficient operation.

[0006] Another object is to provide a blower operated airknife as characterized above that is effective for producing a significantly greater air flow for a given inlet air pressure. A related object is to provide such an airknife that is adapted to produce a higher volume and/or velocity air curtain without increasing the size or operating pressure of the associated blower.

[0007] A further object is to provide a low pressure blower operated airknife of the above kind that is adapted for producing a more effective, higher volume and/or velocity, air curtain with a greater width in the direction of travel of items passing through the air curtain.

[0008] Still another object is to provide a blower-operated airknife of the foregoing type which is adapted for more effectively directing pressurized air curtain streams against both forward and rearward sides of objects passing transversely through the air curtain.

[0009] Yet another object is to provide a blower-operated airknife adapted for directing air streams onto specific separated surfaces of moving items in a processing line.

[0010] A further object is to provide an airknife of the above type which is adapted for the low-pressure direction and application of air-laden particles, and particularly air curtains which carry and deposit pre-atomized liquid particles.

[0011] Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIGURE 1 is a partially diagrammatic depiction of a conveyor system having a blower operated air knife in accordance with the present invention;

[0013] FIG. 2 is an enlarged perspective of the airknife shown in FIG. 1;

[0014] FIG. 3 is a vertical section of the illustrated airknife taken in the plane of line 3-3 in FIG. 2;

[0015] FIG. 3A is an enlarged fragmentary section of the discharge end of the illustrated airknife;

[0016] FIG. 4A is a fragmentary perspective depicting the textured surface of a plate that defines one of the air discharge orifices of the illustrative airknife, such as the plate surface as viewed in the plane of line 4A-4A in FIG. 3;

[0017] FIG. 4B is a vertical section of the plate shown in FIG. 4A, taken in the plane of line 4B-4B;

[0018] FIG. 5A is a fragmentary perspective, similar to FIG. 4A, depicting an alternative form of discharge orifice plate surface;

[0019] FIG. 5B is a vertical section of the plate shown in FIG. 5A taken in the plane of line 5B-5B;

[0020] FIG. 6A is a fragmentary perspective, similar to FIGS. 4A and 5A, showing still another alternative form of discharge orifice plate surface;

[0021] FIG. 6B is a vertical section of the plate shown in FIG. 6A, taken in the plane of line 6A-6A;

[0022] FIG. 7 is a side elevational view of an alternative embodiment of airknife embodying the invention;

[0023] FIG. 8 is a vertical section of the airknife shown in FIG. 7, taken in the plane of line 8-8;

[0024] FIG. 9A is a vertical section of still another alternative embodiment of airknife according to the invention;

[0025] FIG. 9B is a vertical section of an airknife, similar to that shown in FIG. 9A, but depicting an alternative form of air augmenting shroud for the airknife;

[0026] FIG. 10 is a longitudinal section of still a further alternative embodiment of airknife according to the invention;

[0027] FIG. 11 is a vertical section of the airknife shown in FIG. 10 taken in the plane of line 11-11;

[0028] FIG. 12 is a vertical section, similar to FIG. 11, but showing still a further alternative embodiment of airknife according to the invention;

[0029] FIG. 13 is a partially diagrammatic depiction of an alternative embodiment of airknife adapted for the low-pressure application of a curtain of air-laden particles; and

[0030] FIG. 14 is a vertical section of an alternative embodiment of airknife adapted for directing dual pressurized air streams.

[0031] While the invention is susceptible of various modifications and alternative constructions, certain illustrated embodiments thereof have been shown in the drawings and will be described below in detail. It should be understood, however, that there is no intention to limit the invention to the specific forms disclosed, but on the contrary, the intention is to cover

all modifications, alternative constructions and equivalents falling within the spirit and scope of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0032] Referring now more particularly to FIGURE 1 of the drawings, there is shown a conveyor 10 having an illustrative airknife 11 embodying the present invention. The conveyor 10 may be of a conventional type, having a belt 12 trained about rollers 14 for moving items 15 to be processed along a length of the conveyor 10. The airknife 11 includes an elongated housing 16 horizontally supported above the conveyor 10 for directing a relatively narrow width curtain 18 of air across the conveyor belt 12 transverse to the line of movement of the conveyed items. As is known in the art, air currents of such type may be used for various purposes in manufacturing processing, including, but not limited to, forced air drying, cleaning, or cooling of items as they are conveyed through the air curtain.

[0033] The elongated housing 16 of the illustrated airknife 11 is defined by a pair of identical side panels 20 secured by cross bolts 21 and forward and rear end panels 22, 24 respectively, secured at rearward and forward ends of the side panels 20 by longitudinally extending bolts 25 which extend through circumferentially spaced longitudinal passages in the side panels 20. The housing 16 has a pear-shaped cross section, as best depicted in FIG. 3, which includes a generally rounded upper proportion 28 and a downwardly directed tapered lower portion 29 having relatively straight wall sections. The lower tapered housing portion 29 terminates in a pair of downwardly directed plate or flange portions 30 disposed in closely spaced side-by-side relation to each other for defining an elongated slit-like primary air discharge orifice 31. The discharge orifice 31 preferably has a relatively narrow width "w", such as on the order of .042 inches.

[0034] For supplying low-pressure air to the housing 16, the airknife 11 has a blower 32 operable for directing air to the housing 16 via a supply conduit 34. The conduit 34 in this case communicates with an inlet aperture 23 in the upper rounded portion of the rear housing end panel 24. The blower 32 preferably is operable for directing an air supply to the housing 16 at

relatively low pressures, such as less than 10 psi, and preferably about 5 psi. As is known in the art, low-pressure air directed to the housing 16 will exit the elongated discharge orifice 31 in a relatively narrow air curtain which extends across the conveyor belt 12 transversely to the direction of movement of items 15 being conveyed. While for economical reasons it is desirable to use low pressure blowers in such airknives, as indicated above, in conventional airknives, the air volume and/or velocity of the discharging air curtain, as well as its transverse width, may be limited such as to impede its effective use in some processing applications.

[0035] In accordance with the invention, the airknife includes an air-augmenting shroud adapted for increasing the airflow from the knife without the necessity for increasing the air inlet pressure or blower size. To this end, the illustrated airknife 11 has an air-augmenting shroud 35 defined by a pair of fins 36 mounted in predetermined spaced relation on opposite sides of the lower housing portion 29 for defining air passages 38 that communicate with respective elongated auxiliary air discharge orifices 40 parallel to and adjacent opposite sides of the primary discharge orifice 31. The fins 36, which may be inexpensively formed of plastic, in this instance each have a straight planar portion 41 which extends generally parallel to a respective tapered side of the airknife housing 16 and outwardly curved upper portion 42 flared away from the housing 16. For supporting the wings 36, the end panels 22, 24 extend outwardly of the housing side panels 20 and are formed with respective grooves for receiving and supporting the straight planar sections 41 of the wings 36 with a press fit. It will be seen that the wings 36 define the auxiliary air passages 38 along opposite tapered sides of the lower housing portion 29 and the auxiliary discharge orifices 40 are defined between the lower terminal ends of the wings 36 and housing flanges 30. The wings 36 preferably are supported such that the lower terminal ends extend a small distance below the lower ends of the housing flanges 30, such as about 1/8th inch.

[0036] In operation, air flow discharging from the primary discharge orifice 31 is believed to create a relatively lower atmospheric pressure condition in the vicinity of the auxiliary discharge orifices 40 defined by the shroud wings 36 so as to cause ambient air to be drawn through the auxiliary air passages 38 and discharge orifices 40 and be entrained with air emitting from the primary discharge orifice 31. This has been found to increase the volume and velocity of the discharging air flow and cause the air curtain to have a greater transverse width

(i.e., in the direction of items traveling through the air curtain) for more effective processing usage.

[0037] The auxiliary air discharge orifices 40 defined by the shroud wings 36 have a width "a" greater than the width "w" of the primary discharge orifice. The auxiliary air discharge orifices 40 in this instance have a width "a" about three times the width "w" of the primary discharge orifice 31. Preferably, the auxiliary discharge orifices 40 having a width "a" of about $1/8^{th}$ inch and define an overall gap "b" of about 1/2 inch, which encompasses the discharge end of the airknife housing 16, and particularly the primary orifice-defining flanges 30. The auxiliary air passageways 38 defined by the shroud wings 36 preferably extend a length "l" of between about 6 to 9 inches, depending upon the size of the airknife housing 16.

[0038] In keeping with the invention, the surfaces of the airknife 11 and shroud 35 that define the primary and auxiliary discharge orifices 31, 40 are textured or otherwise irregular for reducing eddy current effects and further augmenting and enhancing the discharging airflow. In the illustrated embodiment, the terminal flanges 30 of the airknife housing 16 and lower inside faces of the wings 36 are formed with textured surfaces 45, such as the grooved surface depicted in FIGS. 4A and 4B. The textured surface 45 in this case is defined by a plurality of closely spaced riblets 46 extending in the air flow direction which create the irregular surface. Alternatively, the textured surface may be in the form of dimples 48, such as shown in FIGS. 5A and 5B, or a sharkskin or other pattern 49, such as illustrated in FIGS. 6A and 6B. Such texturing of the orifice-defining surfaces is believed to inhibit eddy currents that can create a drag on the airflows through the discharge orifices 31, 40. The texturing is believed to reduce the coefficient of drag, and hence, permit enhanced air flow. In practice, an airknife with such air augmenting shroud 35 has been found to significantly increase the volume and velocity of the discharging air flow by as much as 25%, without the necessity for increasing the blower size or supply air pressure. With the greater air flow, the effective transverse width of the air curtain also is increased.

[0039] Referring now to FIGS. 7 and 8, there is shown an alternative embodiment of airknife according to the invention wherein items similar to those described above have been given similar reference numerals with the distinguishing suffix "a" added. The airknife 11a has

a housing 16a in the form of an extrusion having a radiused upper wall 51 and a pair of inwardly radiused lower walls 52 which terminate in a pair of inwardly parallel flanges 54 extending the length of the housing 16a. A primary elongated air discharge orifice 31a in this case is defined by an orifice insert 55 supported between the spaced housing flanges 54.

[0040] For augmenting the air flow from the primary discharge orifice 31a, the airknife 11a has a shroud 35a in the form of a pair of curved wings 36a supported by standoffs 56 in generally parallel relation to the inwardly curved housing side walls 52 so as to define auxiliary air passages 38a which communicate from respective outer sides of the housing 16a radially inwardly and then downwardly through auxiliary discharge orifices 40a defined between lower curved side wall portions of the wings 36a and the primary orifice defining insert 55. The insert 55 in this instance has downward and inwardly tapered sides 58 disposed closely adjacent to the lower curved side wall portions of the wings. The wings 36a again encompass and extend a distance below the primary discharge orifice 31a such that an air flow stream discharging from the primary discharge orifice 31a creates a low atmospheric pressure immediately downstream of the auxiliary discharge orifices 40a for drawing air through the auxiliary air passages and discharge orifices 38a to augment the air flow emitting from the primary discharge orifice 31, as described above. Again, the faces of the insert 55 and shroud 36a that define the primary and auxiliary discharge orifices 31a, 40a may be textured for reducing eddy current air drag.

[0041] Referring now to FIGS. 9A and 9B, airknives are depicted that have alternative shroud configurations that may be used with the airknife housing shown in the FIGS. 1-3 embodiment for effecting greater auxiliary air flow on one side of the primary discharge orifice than on the other side. With reference to FIG. 9A, an airknife 11b is shown which has a housing 16b similar to that previously described, and a shroud 35b which comprises a substantially straight wing 60 generally parallel with a straight downwardly tapered lower end of the airknife housing 16b for defining a substantially uniform width auxiliary air passage 61 and a second wing 62 disposed at an acute angle to the other side of the housing 16b for defining an auxiliary air passage 64 that converges in a downward direction toward a respective auxiliary discharge orifice 40b. The shroud wing 62 has an outwardly flared upper end 65 and a cylindrical lower end 66 which, together with the airknife housing 16a, defines the auxiliary discharge orifice 40b on one side of the primary discharge orifice 31b and which extends below

the wing 61 on the opposite side of the housing 16b. The larger auxiliary air passage 64 defined by the angled wing 62 enables a greater auxiliary air flow on one side of the air curtain than on the opposite side and the lower terminal end 66 of the wing 62 directs that auxiliary air flow for a greater distance than the relatively shorter wing 60. With reference to FIG. 9B, the airknife 11c is similar to that shown in FIG. 9A, except that an angled wing 62c, which extends below the level of a parallel wing 60c, terminates with a curved lower end 66c.

[0042] With reference to FIGS. 10 and 11, there is shown still a further alternative embodiment of airknife according to the invention, wherein items similar to those described above have been given similar reference numerals with the distinguishing suffix "d" added. In this case, an airknife 11d is provided that has a cylindrical housing 16d with an air inlet 35d at one axial end thereof and a longitudinally extending insert 55d mounted in the bottom of the housing 16d, which defines an elongated primary air discharge orifice 31d. An air augmenting shroud 35d in this instance is defined by a cylindrical member which encompasses the airknife housing 16d and has a longitudinal insert 70 in a bottom side that defines a final elongated air discharge orifice 71 in closely spaced and aligned relation to the primary discharge orifice 31b of the housing. Upstream and downstream ends of the inserts 55d, 70 define elongated auxiliary orifices 40d which communicate between the final discharge orifice 71 and auxiliary air passages 38d defined between the cylindrical side walls of the housing 16d and shroud 35d which in turn communicate with circumferentially spaced air inlet passages 72 in the shroud 35d.

[0043] In operation of the airknife 11d, low pressure air introduced into the airknife housing 16d through the inlet 35d discharges through the elongated primary discharge orifice 31d directly into the final elongated discharge orifice 71 defined by the shroud insert 70, creating a low pressure condition in the vicinity of the auxiliary air orifices 40d defined between the inserts 55d, 70. This low pressure zone causes an augmenting air flow to be drawn through the auxiliary air passages 38d defined between the cylindrical housing 16d and shroud 35d, thereby increasing the volume and velocity of the air curtain discharging from the final elongated discharge orifice 71.

[0044] With reference to FIG. 12, a further alternative embodiment of airknife 11a is disclosed which comprises a pear-shaped airknife housing 16e, similar to that disclosed in FIGS. 1-3, having a cylindrical shroud 35e generally similar to that shown in FIGS. 10 and 11. An elongated primary discharge orifice 31e defined between lower terminal flanges 30e of the housing 16e in this case discharges air through an elongated relatively narrow width longitudinal opening 75 in the shroud 35e disposed immediately below the primary orifice defining flanges 30e. Longitudinal edges of the opening 75 and terminal ends of the housing flanges 30e define elongated auxiliary air discharge orifices 40e which communicate with auxiliary air passages 38e defined by the space between the housing 16e and shroud 35e, which in turn communicate with air inlet passages 72e in the shroud. Again, air discharging from the primary discharge orifice 31e will create a low pressure condition within the elongated shroud opening 75, in turn causing an augmenting air flow through the auxiliary discharge orifices 40e.

[0045] In accordance with a further aspect of the invention, the airknife of the present invention may be used for the low pressure direction and application of air laden particles. To this end, with reference to FIG. 13, there is shown an airknife 11f having a housing 16f and shroud 35f similar to that shown in FIGS. 10 and 11. The airknife 11f in this instance has a liquid atomizer 80 operable for directing atomized liquid droplets into a blower directed air stream passing through the inlet conduit 34f and communicating with the airknife housing 16f. The atomizer 80, which may be of a conventional type, comprises a nozzle body 81 having an axial liquid flow passage 82 connected at its upstream end with a liquid supply line 84 and having a mixing nozzle 85 adjacent a downstream end. Pressurized air from an air supply line 86 communicates radially with liquid passing through the nozzle 85 for atomizing the liquid into fine droplets, prior to radial introduction into the air inlet conduit 34f. The preatomized liquid droplets will be carried by the air stream directed into the airknife housing 16f and will discharge with the air curtain, for low pressure application onto a substrate or items being conveyed through the air curtain, or for discharge into the atmosphere. The air augmenting shroud 35f again enhances the reliable direction and application of the air laden particles, notwithstanding the relatively low pressure air supply.

[0046] Referring now to FIG. 14, there is shown an alternative embodiment of airknife in accordance with the invention adapted for directing dual, air-augmented pressurized fluid

streams onto passing objects of a processing line, wherein items similar to those described above have been given similar reference numerals with the distinguishing suffix "g" added. The airknife 11g in this case also has a pear-shaped housing 16g into which a pressurized air and/or an air atomized liquid particle stream is introduced from an inlet opening 23g in an end panel 24g thereof. The lower end of the housing 16g has oppositely directed curved terminal ends 90 which define a discharge opening 91.

[0047] In carrying out a further aspect of the invention, an air divider 92 is mounted in fixed relation to the housing discharge opening 91 for defining a pair of diverging primary elongated air discharge orifices 31g. The air divider 92 in this case is in the form of a triangular block which can be bolted or otherwise fixed between the housing end panels 24g. The triangular air divider block 92 is supported such that upper angled surfaces 94 thereof meet centrally within the housing discharge opening 91. Each angled surface defines one elongated side of a primary discharge orifice 31g, the other side of which is defined by an adjacent outwardly curved end 90 of the housing. The angled surfaces 94 of the air divider block 92 in this case are disposed at an angle "ϕ" of about 90 degrees to each other for directing diverging primary air streams 45 degrees forwardly and rearwardly of a vertical axis 93 of the airknife, as viewed in FIG. 14. Alternatively, the air diverting surfaces 94 of the divider 92 may be formed at an angle "ϕ" of between 25 and 100 degrees. In each case, the lower curved ends 90 of the housing terminate in generally parallel relation to the air divider surfaces 94.

[0048] For augmenting the air flow from the primary discharge orifices 31g, the airknife 11g has a shroud 35g in the form of a pair of fins or wings 36g supported in spaced in relation to opposite housing sidewalls 52g so as to define a pair of auxiliary air discharge passages 38g each communicating with a respective auxiliary air discharge orifice 40g in adjacent parallel relation to one of the primary discharge orifices 31g. Lower terminal ends 95 of the wings 36g in this instance curve in parallel relation to the curved lower terminal ends 90 of the housing 16g such that the auxiliary air discharge orifices 40e extend generally parallel to, but larger in size, than the primary air discharge orifices 31g.

[0049] The wings 36g in this case are adapted for easy mounting and disengagement with the housing 16g. Outwardly turned upper ends 96 of the wings are insertable and releasably engageable with respective integrally formed hooks 98 of the housing in response to downward pivotal movement of the wings 36g, while lower ends 95 of the wings are retained in fixed relation to the bottom of the housing by respective bolts 25g extending between the housing end panels 24g. The auxiliary air passages 38g defined by the wings 36g communicate between inlet openings 99 at an upper end thereof that communicate with ambient air and the auxiliary discharge orifices 40g at the lower end. The auxiliary air passages 38g in this instance taper slightly inwardly and in a downstream direction.

[0050] In operation, similar to the previous embodiments, airflow streams discharging from the primary discharge orifices 31g create low atmospheric pressures immediately adjacent the auxiliary discharge orifices 40g which draw ambient air through the auxiliary air passages 38g for augmenting the air flow emitting from the primary discharge orifices 31g. Again, the angled surfaces 94 of the air diverter block 92 and the adjacent faces of the wings 36g may be textured for reducing eddy current air drag.

[0051] It will be appreciated that the airknife 11g is adapted for enhanced utility and operating efficiency in processing lines. First, when the airknife 11g is mounted for directing elongated air curtains on items moving in a direction transverse to the elongated air discharge orifices 31g, as is commonly the case, the discharging air streams are adapted for more effectively processing front and rear sides of the conveyed items being processed. In this regard, as items are conveyed past the airknife 11g, the downwardly and rearwardly directed air stream from one of the air discharge orifices 31g more effectively impinges upon a front side of the item as it approaches the airknife and the downwardly and forwardly directed air stream from the other discharge orifice 31g more effectively impinges a rear side of the conveyed item as it is proceeding away from the airknife. Moreover, it will be seen that when items being processed are conveyed under the airknife in a direction parallel to the elongated discharge orifices 31g, the diverging air streams may be directed on specific areas of the items being processed, without application to intermediate areas. This is particularly advantageous when the airknife is utilized for directing an atomized liquid carrying air streams, since the dispensed liquid can be more efficiently directed and utilized.

[0052] From the foregoing, it can be seen that blower-operated airknife of the present invention is adapted for more efficient operation, enabling greater air flow for a given air inlet pressure. The airknife is adapted for producing a higher volume and/or velocity air current without increasing the size or operating pressure of the associated blower and discharges a curtain of air having a greater effective transverse width. The air curtain further is adapted for the reliable, low pressure direction and application of air laden particles, such as preatomized liquid particles.